Case 1. Energy consumption and price forecasting, 1-day ahead hourly

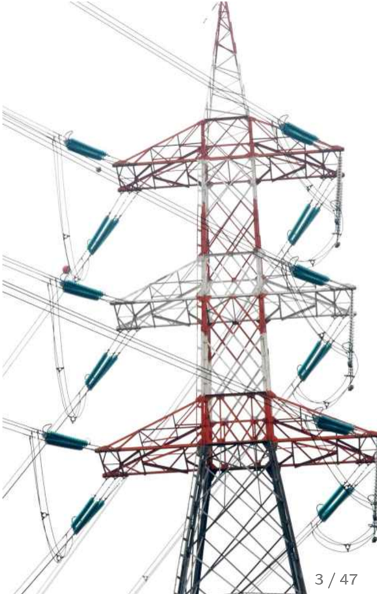
The components of multivariate time series with periodicity

Time series:

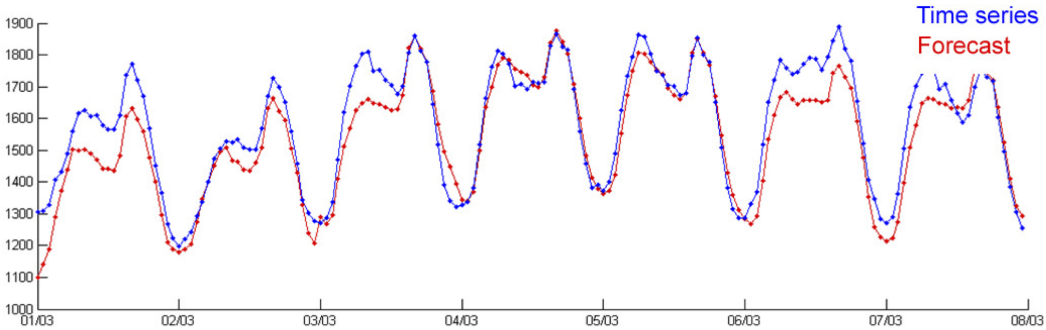
- energy price,
- consumption,
- daytime,
- temperature,
- humidity,
- wind force,
- holiday schedule.

Periodicity:

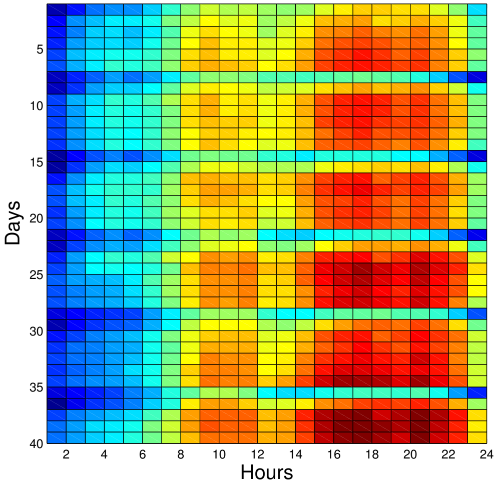
- one year seasons (temperature, daytime),
- one week,
- one day (working day, week-end),
- a holiday,
- aperiodic events.



Energy consumption one-week forecast for each hour



The autoregressive matrix, five weeks



The autoregressive matrix and the linear model

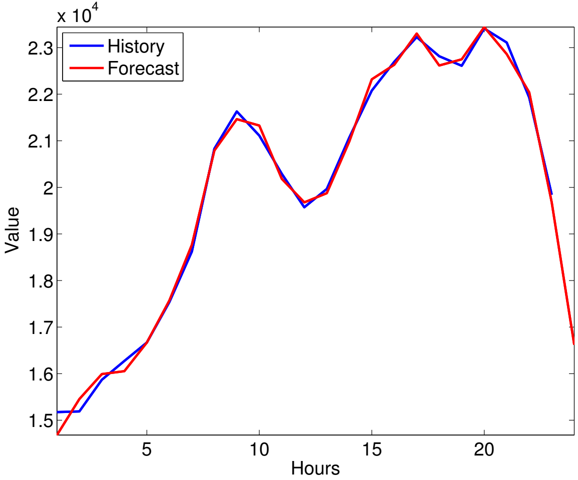
$$\underset{(m+1)\times(n+1)}{\mathbf{X}^*} = \left[\begin{array}{c|cccc} \hat{s}_T & s_{T-1} & \dots & s_{T-\kappa+1} \\ \hline & & & \\ s_{(m-1)\kappa} & s_{(m-1)\kappa-1} & \dots & s_{(m-2)\kappa+1} \\ \dots & \dots & \dots & \dots \\ s_{n\kappa} & s_{n\kappa-1} & \dots & s_{n(\kappa-1)+1} \\ \dots & \dots & \dots & \dots \\ s_\kappa & s_{\kappa-1} & \dots & s_1 \end{array}\right] = \left[\begin{array}{c|c} \underset{1\times 1}{\hat{s}_T} & \underset{1\times n}{\mathbf{x}_{m+1}} \\ \hline \underset{m\times 1}{\mathbf{y}} & \underset{m\times n}{\mathbf{X}} \end{array}\right].$$

In terms of linear regression:

$$\hat{\mathbf{y}} = \mathbf{f}(\mathbf{X}, \mathbf{w}) = \mathbf{X}\mathbf{w},$$

$$\hat{y}_{m+1} = \hat{s}_T = \langle \mathbf{x}_{m+1}, \hat{\mathbf{w}} \rangle.$$

The one-day forecast: expected error is 3.1% working day, 3.7% week-end



The model $\hat{\mathbf{y}} = \mathbf{f}(\mathbf{X}, \mathbf{w})$ could be a linear model, neural network, deep NN, SVN, . . .

The model performance criteria and forecast errors

Stability:

- the error does not change significantly following small changes in time series,
- the distribution of the model parameters does not change.

Complexity:

- the number of parameters (elements in superposition) is minimal,
- the minimum description length principle holds the William Ockham's rule.

Error: the residue $\varepsilon_j = \hat{y}_j - y_j$ for

- mean absolute error and (symmetric) mean absolute percent error

$$RSS = \sum_{j=1}^{r} \varepsilon_j^2, \quad MAPE = \frac{1}{r}\sum_{j=1}^{r} \frac{|\varepsilon_j|}{|y_j|}, \quad sMAPE = \frac{1}{r}\sum_{j=1}^{r} \frac{2|\varepsilon_j|}{|\hat{y}_j + y_j|}.$$